Tagging and Playback Studies to Toothed Whales

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LONG-TERM GOALS

There has been growing recognition that atypical mass strandings of beaked whales may coincide with naval exercises that use mid-frequency sonar, but the causal chain of events from sound exposure to stranding has not been elucidated. Even less is known about potential risks to other species of odontocetes or for other signals. The proposed research is part of a collaborative research program whose long-term goals are to compare responses of beaked whales and other odontocetes to playbacks of mid-frequency sonar sounds and other anthropogenic and natural signals. The ultimate long –term goals of the overall program are to predict the distribution of species at risk from sonar, to define dose:response curves for risk to beaked whales and other whales during exposure to naval sonars, and to suggest improvements for monitoring and mitigation. The specific data gap that the project from this year aims to fill is a lack of baseline data from pilot whales. The study of large delphinids that are relatively easy to tag is important as results so far suggest that they may have different responses to sonar, suggesting very different risk factors for stranding or injury, compared to beaked whales, which seem to silence and flee from sounds of sonar and predators. The behavior of the pilot whales is complex and variable enough, that even though the BRS and 3S projects together have more playbacks of sonar and killer whale sounds to them than any other species, we anticipate that considerably more work on baseline behavior will be needed along with more playbacks to resolve issues around variability of response. Some of the pilot whales responded to playbacks of sonar and killer whale sounds by increasing their calling rates, and with increased social cohesion with less consistency in avoidance responses than the beaked whales tested to date. No sonar playbacks have been conducted with any beaked whale species outside of a naval range, where they frequently are exposed to naval sonars. Another long term goal of this project is to conduct playbacks of sonar and killer whale sounds in areas with little sonar usage to Cuvier's beaked whale, *Ziphius cavirostris*, which is the species most represented in the record of atypical mass strandings associated with naval maneuvers.

OBJECTIVES

The main objectives of this 3 year study involve:

- Designing, planning, permitting, and conducting a study involving sound playback experiments with beaked and other whales carrying sound and orientation recording tags.

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- Develop, test, and validate shipboard Passive Acoustic Monitoring (PAM) of marine mammal vocalizations for Detection, Classification, and Localization (DCL) during survey, focal follow and playback.
- Merge a survey mode with a focal follow mode that will involve tagging and controlled exposure
- Map the range of doses of noise to which animals are exposed
- Collect environmental data to support habitat modeling
- Identify and improve management of habitats that host sensitive species (consistent with ACCOBAMS)

All of these objectives except the last were primary goals of the Med09 cruise conducted during the first year of this project. As described in last year's report, permits were obtained, protocols developed and successfully implemented during the cruise in order to meet all of these objectives except that no beaked whale was successfully tagged, so there was no opportunity to conduct a playback to a tagged beaked whale during this cruise. The Med09 cruise and teams did identify excellent opportunities for studying pilot whales in the Alboran Sea from smaller vessels. The primary objective of this year's field work was developing methods and conducting a cruise to study social behavior and acoustic communication of pilot whales in an effort to understand the underlying causes and functions of the variability in baseline behavior observed in pilot whales, and to expand the database of baseline behavior from tagged whales. The field logistics worked out during 2010 will also enable playback experiments with a smaller sound source during 2011.

APPROACH

This year's field effort was designed to tag pilot whales and add observational methods to improve our ability to study social behavior and communication, with a special focus on how communication may mediate social defenses against threats. An important method for this involves simultaneous deployment of multiple tags on the same group. We observed each group for long enough before tagging to select specific animals for tagging because of an observed association. We fine tuned the behavioral protocols developed by the earlier BRS Med09 and 3S projects (Canadas et al. 2009, Visser et al. 2009), adapting them for use on a smaller observation vessel and for simultaneous deployment of multiple tags on the same group, emphasizing behaviors related to cohesion. An important measure for this is inter-individual distances. While the DTAG contains pressure and acceleration sensors necessary to record the depth and movement of the animal, measurements of velocity are not precise enough to support 3D tracks sufficient for precise measurement of inter-individual distances. When two tagged individuals vocalize close enough that signals are recorded on the other tags, an estimate of distance between the whales can be derived. We also developed and tested a system to provide precise locations of photo-identified whales. This system inputs to a digital camera, data from a GPS and compass accurate to several degrees. Distance can be estimated using two lasers collimated at a separation of 10 cm (Webster et al. 2010). Finally, we tested low-amplitude playbacks of a high-frequency chirp that can enable synchronization of the clocks on tags, and facilitate localization for these measurements.

WORK COMPLETED

Table 1 lists the pilot whales tagged during the field effort. The time indicates the duration of the focal follow. Individual whales were tagged for shorter periods of time within the follow.

Table 1. Pilot whales tagged, and beaked whale tagging attempts for Med10 cruise in the Alboran Sea.

Date	Species	Animal ID*	Group size	Time (start-end)
19-Aug-10	*Globicephala melas*	A	36	local 10.10-19.40
19-Aug-10	*Globicephala melas*	B	36	local 10.10-19.40
22-Aug-10	*Globicephala melas*	A	49	local 12.31-21.00
22-Aug-10	*Globicephala melas*	B	49	local 12.31-21.00
26-Aug-10	*Globicephala melas*	A	21	local 12.10-21.00
26-Aug-10	*Globicephala melas*	B	21	local 12.10-21.00
02-sept-10	*Ziphius cavirostris*	Unknown	4	local 14.43-17.22
03-sept-10	*Globicephala melas*	A	11	local 15.40-20.30
03-sept-10	*Globicephala melas*	B	11	local 15.40-20.30
03-sept-10	*Globicephala melas*	C	11	local 15.40-20.30
03-sept-10	*Globicephala melas*	D	11	local 15.40-20.30
05-sept-10	*Ziphius cavirostris*	Unknown	3	local 10.10-11.00
05-sept-10	*Globicephala melas*	A	14	local 14.25-20.30
05-sept-10	*Globicephala melas*	B	14	local 14.25-20.30
05-sept-10	*Globicephala melas*	C	14	local 14.25-20.30
05-sept-10	*Globicephala melas*	D	14	local 14.25-20.30
05-sept-10	*Globicephala melas*	E	14	local 14.25-20.30
05-sept-10	*Globicephala melas*	F	14	local 14.25-20.30

The cruise was very successful, with 16 pilot whales tagged, all with multiple animals tagged within a social group. We also conducted focal follows on two *Ziphius cavirostris* in sea conditions suitable for tagging, but were not able to tag this difficult species.

RESULTS

An important goal of this study involved developing methods to collect baseline data on how pilot whales use acoustic communication to maintain social cohesion. The results are very promising for achieving this goal. One very interesting result from tagging multiple animals simultaneously was the high level of synchrony in diving behavior. Figure 1 overlays the dive profiles of two pilot whales tagged simultaneously: gm10_231a&b. The first two deep foraging dives were synchronous, but on the third deep foraging dive gm10_231b (red line) broke off the descent while gm10_231a made a deep foraging dive. The inset shows that even on the shallow dives, the two whales synchronized dives quite precisely. We interpret cases like the third deep dive as separations, raising questions about how the whales reunite.

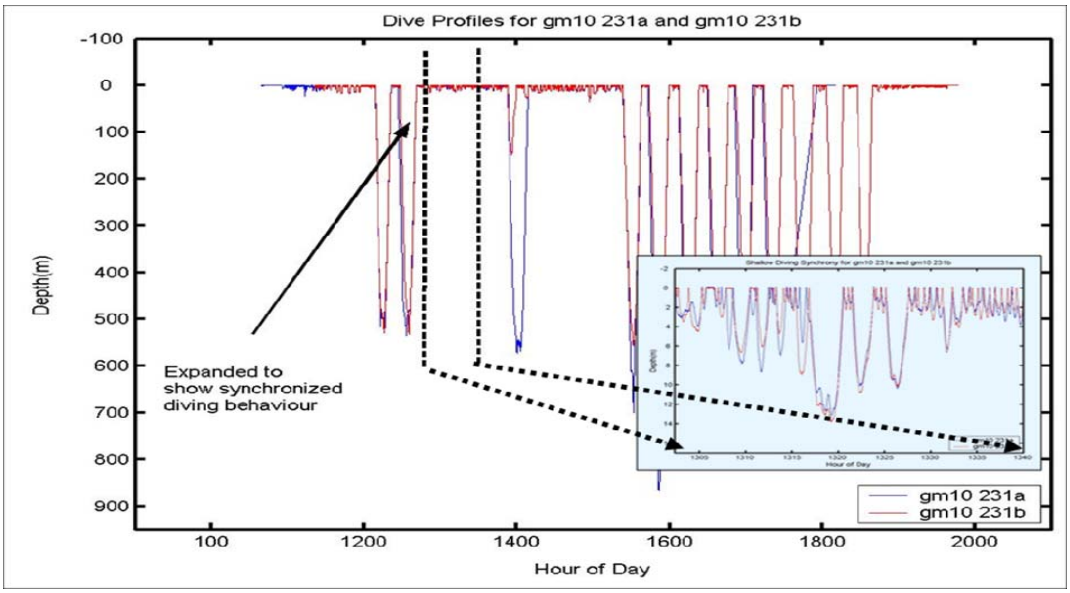

Figure 1. Dive profiles of two pilot whales (gm10_231a&b) tagged simultaneously in the Alboran Sea during the Med10 cruise.

Figure 2 blows up this third deep foraging dive and shows the calling behavior of each whale. The whales were silent at the surface and made a few calls on descent. The foraging whale made buzzes associated with attempts to capture prey (Soto et al. 2008), and was mostly silent during the initial part of its ascent. However, during the last 2/3 of the ascent, gm10_231a started producing a series of repeated calls. As gm10_231a reached about 200m, gm10_231b also started producing a series of calls.

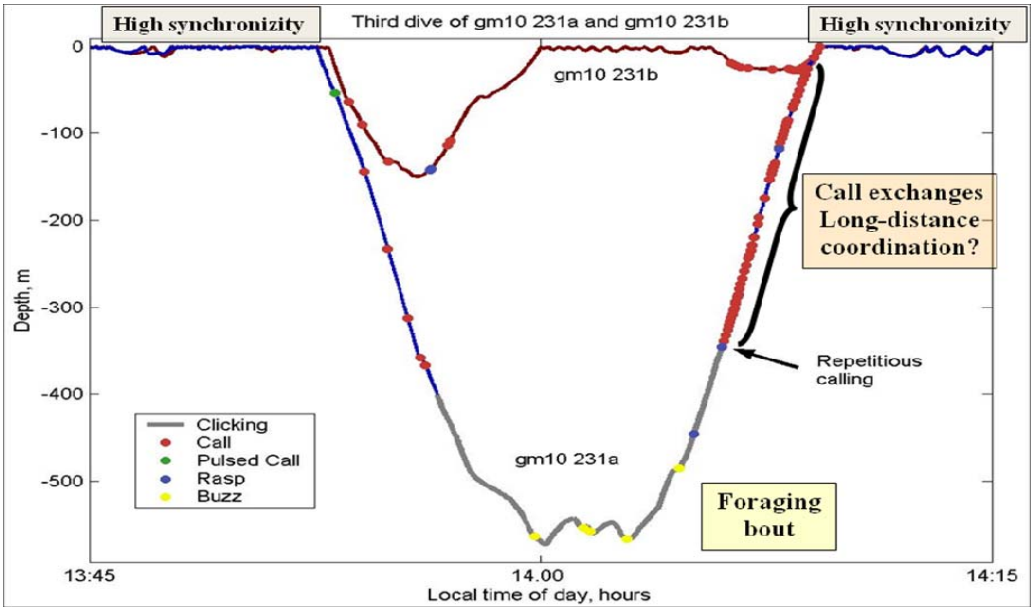

Figure 2. Blow up of dive 3 from gm10_231a&b with vocal behavior indicated as per the legend. Calls, pulsed calls and rasps are presumably social signals while buzzes signify prey capture attempts.

Figure 3 shows how we can discriminate calls from the tagged whale (focal) from calls from other whales (non-focal). There is a clear intensity difference at this range of 30-40 m, but this technique is less useful when whales are separated only by a few meters.

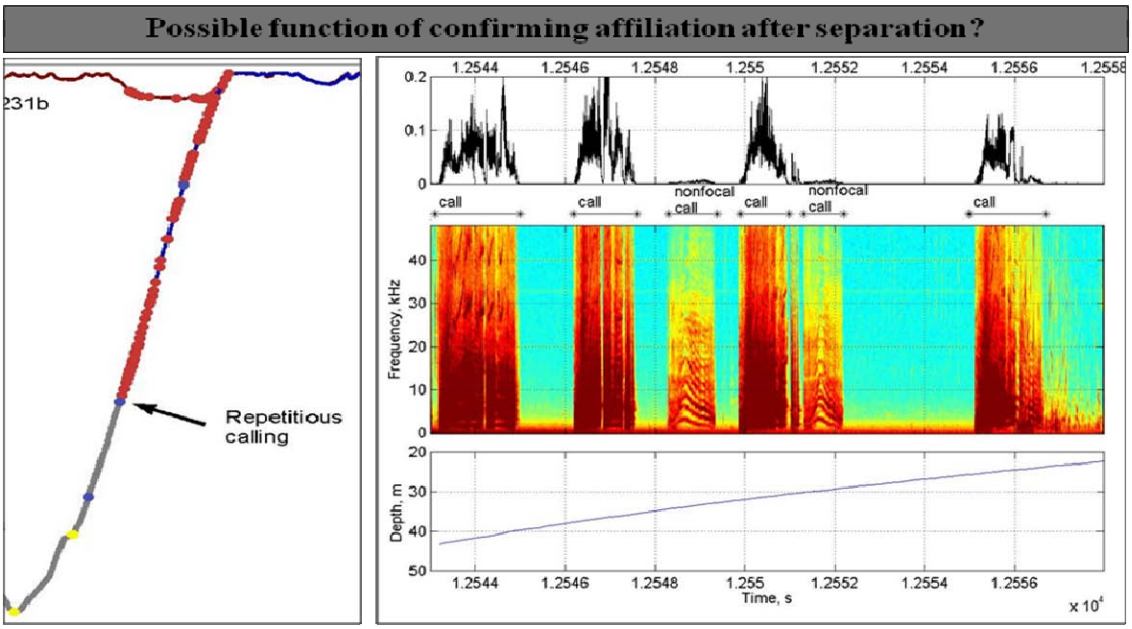

Figure 3. Blow up of the end of the ascent of gm10_231a from its third deep foraging dive, with a spectrogram of the acoustic record showing its own loud calls and the fainter calls from gm10_231b.

Figure 4 shows the results of our test of the synchronization chirps played back to tagged whales. No responses were obvious in the tag record and the chirp signals on the tag are perfect for synchronization.

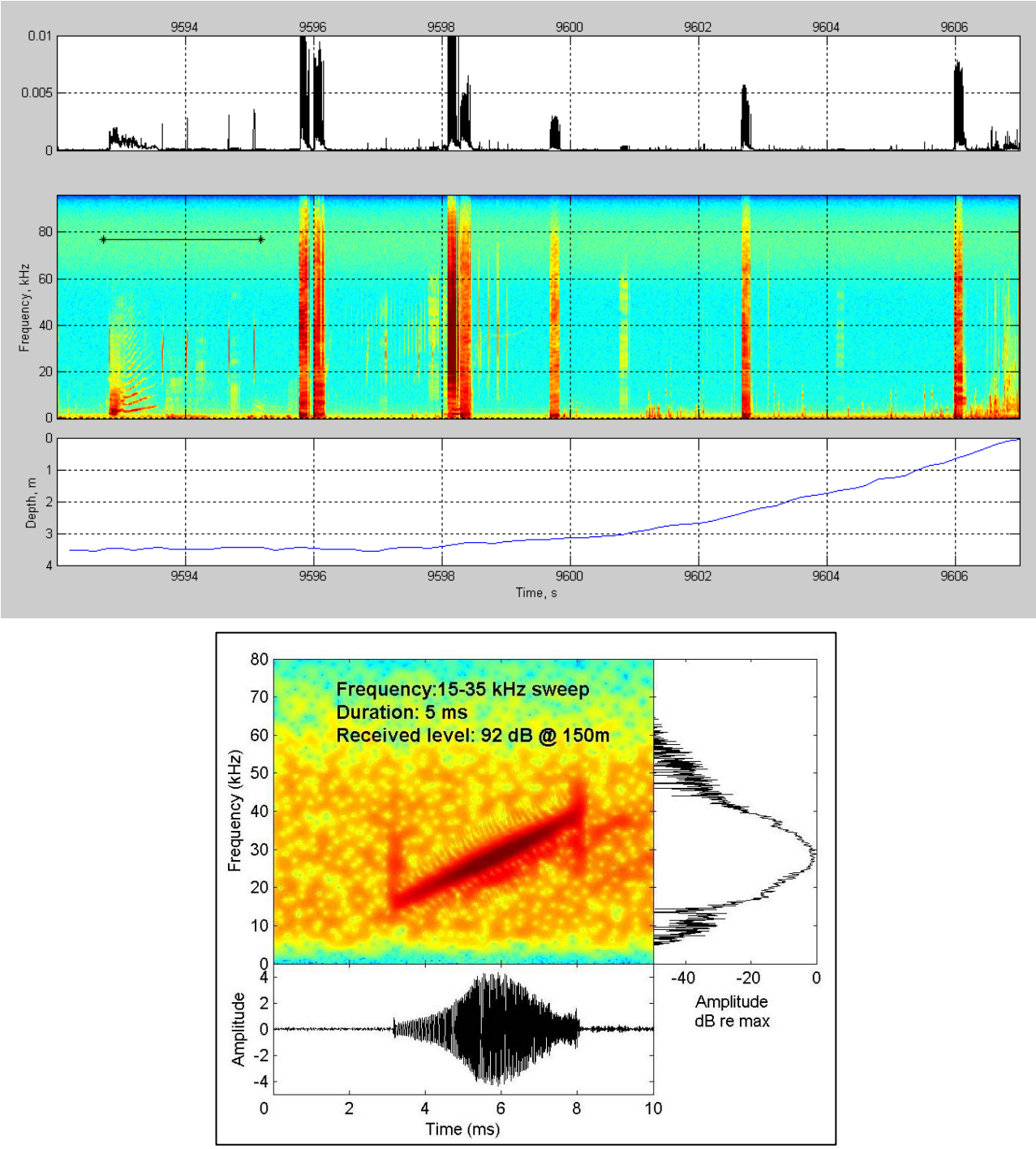

Figure 4. Playback of low-level high frequency FM chirps used to synchronize the tags are audible at a range of ~150m.

IMPACT/APPLICATIONS

This study aims to reduce risks to whales and to improve monitoring and mitigation measures by defining how beaked whales and other species are affected by sonars, by measuring the exposures required to elicit the responses, and by identifying beaked whale habitats. The Med09 and Med10

cruises provided important survey and photo-id data on beaked whales and other cetaceans in the western Mediterranean which are being used for habitat modeling (see annual report by Cañadas. While the Med09 cruise was not able to tag a beaked whale and conduct a sonar playback, it did demonstrate the required capabilities and trained the teams for conducting controlled exposure experiments outside of a Navy underwater range, where vocalizations can be recorded from a permanent bottom-mounted hydrophone array. The Med10 cruise developed and tested methods to measure social behavior and communicaiton in pilot whales, and collected significant amounts of baseline data for pilot whales, with a sample size commensurate with the extensive samples of playbacks to pilot whales from the BRS and 3S projects.

RELATED PROJECTS

ONR: CANADAS: Beaked whales and pilot whales in the Alboran Sea (SW Mediterranean): research towards improved science-based mitigation strategies for risks from man-made sound. : N000140910536 and N000141010709

ONR: Behavioral Responses of Odontocetes to Playback of Anthropogenic and Natural Sounds N00014-07-1-0988

ONR: Cetaceans and Naval Sonar: Behavioral Response as a Function of Sonar Frequency. Grant Number: N00014-08-1-0661

ONR: ARTS DTAG project: N000141010380

SERDP: Acoustic Response and Detection of Marine Mammals on Navy Ranges Using a Digital Acoustic Recording Tag.

Naval Postgraduate School: Dtagging and analysis of studies on effects of naval sounds on marine mammals in waters off southern California

Naval Oceanographic Office: Behavioral Response Study (BRS-07) Analysis and Supplemental Funding for BRS08

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